Susquehanna River Basin
A Research Community
Hydrologic Observatory

NSF-Funded Infrastructure Proposal
in Support of
River Basin Hydrologic Sciences
• **Fundamental Problem:**

*How Do Humans and Climate Impact the Sustainability of Water Resources in Large River Basins?*

Addressing this problem will require scientists to assess climate and terrestrial feedbacks across multiple scales and physiographic conditions to better define the roles that terrain, ecology, climate, and geology play in partitioning water, energy, and nutrients across the complex environmental systems that make up the river basin.
Context

Hydrologic Regions

Physiographic Regions
Advancing River Basin Science:

As disciplinary scientists, we will need to reexamine our individual hypotheses to embrace phenomena and processes spanning multiple scales of time, space and process within and across the river basin.
Our goal is to improve the scientific basis for forecasting and prediction of water resources such that society can make better choices concerning the impacts of climate and anthropogenic change on local, regional and global water problems. As such, terrestrial hydrologic science will require a paradigmatic shift which embraces traditional disciplines but focuses on cross-disciplinary and cross-scale scientific inquiry.
Our approach is to design and implement an integrated observing system for water, energy and biogeochemical cycles across the river basin. Advances in river basin science cannot move forward without a more integrated observing system, where the atmosphere, vegetation, geochemical and hydrologic processes are all observed coherently from headwaters to estuary.
How to Move the Forward:

- Organize the Scientists
- Form the Science Hypotheses
- Plan the Writing & Support Teams
- Schedule Activities to Prepare NSF Proposal
Proposal Strategy:

1) A Network of Testbeds (Watersheds)

2) Cross-Cutting Science Themes
The Design Team:

Given that the SRB Observatory is to be an NSF-funded infrastructure proposal, it is crucial that we inform, coordinate, and cooperate with a broad spectrum of scientists about what we are doing to advance river-basin science, and what it will mean to their research.

CUAHSI WILL SUPPORT RESEARCH INFRASTRUCTURE!!
Proposed Testbeds

Appalachian Plateau (U)
- Roberts Run
- Licks Run

Valley & Ridge
- Shaver Creek
- Spring Creek

Appalachian Plateau (G)
- Young Womans Creek
- Chemung River
- Catatonk Creek
- Otsego Lake

Valley & Ridge
- Mahontango

Piedmont (K)
- Conestoga Creek

Piedmont (C)
- ???

Valley & Ridge (Juniata, Raystown Lake)
The Hydrologic landscapes of the SRB
The Hydrologic landscapes of the SRB
Hydrologic Landscapes: Similarity Kernel
Conceptual Hydrologic Model: Susquehanna River
Potential Cross-Cutting Science Themes

- SRB Hydrosience Cyberinfrastructure
- Wired/Wireless Embedded Technology
- Predicting Climate Change & Basin Water Resources
- Wetlands, Ecohydrology, and Biogeochemical Processes
- Nitrogen Cycle
- Land Surface Hydrology/Remote Sensing
- Hydropedology and the Soil Landscape
- Fluvial Systems and Sediments
- Human Dimension & Policy: Sustainable Water Resources
- Detecting Hydrologic Change
Partners at this Stage

- SUNY Binghamton
- Cornell University
- Columbia University
- US Geological Survey
- NOAA, National Weather Service
- USDA, ARS
- Smithsonian (SERC)
- Syracuse University
- University of Maryland
- Penn State University
- Chesapeake Research Consortium
- Invitation to National & International Scientists
USGS Gages
Observation Wells
Evaporation Transpiration Recharge Arrays (ETR)

4-D atmosphere, land-surface, stream, subsurface observing system, where measurements are collected as a coherent whole, such that gradients and fluxes can be determined at all interfaces (land-surface, water table, stream, vegetation, etc.).
Evaporation Transpiration Recharge Arrays
Design Objectives

- Design in association with NOAA & State Climatologists ETR Arrays to measure precipitation, evaporation and transpiration over the SRB & to provide quantitative estimates of forcing in space and time.

- Install and operate a network of ETR Arrays for surface and subsurface measurements to close the water balance.

- Implement a preliminary integrated surface-groundwater model of the SRB to design an optimal flow & nutrient observing system network.

- Design locations for ~13 state-of-the-art stream gages to USGS network
**Data Development Activities**

- **Topography**
  - Digital elevation models
  - 10 meter resolution (National Elevation Dataset)
- **Streams**
  - Delineated from DEM
  - USGS cross-sectional data correlated with Strahler stream order
  - Channel elevation extracted from DEM
- **Vegetation & Soil**
  - VEMAP: LAI and vegetation type
  - Root and leaf dimensions, canopy resistance vegetation type
  - STATSGO: soil type and data
  - Manning’s roughness grain size
- **Reservoirs**
  - Only DA > 40,000 acre-feet (~ grid cell)
  - Flow versus depth data from USDOI
• Climate
  – Temperate (controlled by polar front, prevailing westerlies & Atlantic)
  – Orographic effects (P:35-45”, ET:15-50”)
• Drainage
  – 71,410 km²
  – Main channel: 714 km
  – Headwaters: Finger lake uplift and Appalachian mountain and plateau
  – Mouth: Chesapeake Bay, MD
• Physiography
  – Appalachian plateau
  – Ridge & Valley
  – Piedmont and Coastal Plain
• Hydrogeologic Features
  – Flat/folded sandstone and shale
  – Carbonate valleys
  – Igneous dikes, sills, and fractures
Detecting Hydrologic Change

- On seasonal to decadal time scales, soil moisture, subsurface fluxes influence the frequency and magnitude of floods and droughts.
- Climate variability and land use changes force a complex exchange of surface-subsurface fluxes across interfaces.
- The transport of contaminants is tightly coupled to the hydrologic problem defined above.
- Present observing systems are insufficient to establish impacts on or test hypotheses about subsurface response to climate variability and/or land use change.
- Necessary to develop the Conceptual Model for Soil/Hydrogeologic/Hydroclimatic
Interpretation: (preliminary, for discussion)

- The Neuse river responds dramatically to annual, interannual and decadal oscillatory modes in the hydroclimatic system.
- The strongest oscillatory modes are associated with the annual cycle and harmonics of the annual mode.
- There apparently is more than one annual mode, possibly due to the different storm types observed in the basin.
- The interannual time scale is ~ 4 yrs
- The decadal oscillation ~ 10 yrs
Why an Observatory?

• The multiple connections of streams, hillslopes and aquifers within a single drainage basin, and their complex mass and energy exchanges across the stream-groundwater and soil-moisture-groundwater interfaces are poorly understood.

• These complex exchanges of mass and energy are essential to evaluating the state of water resources, hydrochemical responses, ecological conditions, timing and magnitude of floods, droughts, landuse and climate change.

• The fundamental problem is that the existing climate-surface water-groundwater observation network is insufficient to support hydrologic science or the management of the nations water resources.
Why an Observatory?

- Understanding the hydrologic cycle is critical to solving local to regional problems related to global climate change, biogeochemical cycling, ecosystem and landuse effects, and environmental management.
- A scientifically designed observing system will address linkages and feedbacks between the global-to-regional hydrologic cycle, the transport of mass and energy, and the evolution of landforms, ecology and landuse.
- The observatory will concentrate scientific expertise and infrastructure sufficient to test fundamental scientific hypotheses on process and prediction at each scale of interest.